

Results of the Software Process Improvement Efforts of the Early Adopters in NAVAIR 4.0

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FOREWORD

The results of the process improvement efforts described in this report were achieved between 1990 and 2007 within Code 4.0 of the Naval Air Systems Command (NAVAIR) at the following locations: Patuxent River, Maryland; Lakehurst, New Jersey; Orlando, Florida; and China Lake and Point Mugu, California. These efforts were part of a Code 4.0 initiative to improve the maturity of the software development processes, to realize cost savings, and to deliver higher quality products to the Fleet. These efforts were, and continue to be, supported by funding from the Software Engineering Department, Code 4.1.E.

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13. ABSTRACT

(U) This paper is an overview of the process improvement efforts of the Naval Air Systems Command's (NAVAIR) Air 4.0, Research and Engineering Competency. It focuses on 24 software engineering teams within the U.S., and specifically on the six teams that were early adopters: the AV-8B Joint System Support Activity; the E-2C, EA-6B, P-3C, and Tactical Aircraft Electronic Warfare Software Support Activities; and the F/A-18 Software Development Task Team. These teams ranged in size from less than 10, to more than 70 NAVAIR software engineers and support contractors. The process improvement efforts described in this paper began in the 1990s and early 2000s. Their process improvement tool sets included the Capability Maturity Model, the Capability Maturity Model (CMM)[®] Integration, the Personal Software Process (PSP), the Team Software Process (TSP), the Earned Value Management System (EVMS), the High Performance Organization, and the Team Software Process for Multiple Teams (TSPm)SM.

(U) By 2005, the early adopters had achieved impressive results: the first CMM Level 5 rating in the Navy, the second EVMS certification in the Federal Government, two teams achieving CMM Level 4 in less than half the normal time, reductions in software defect densities between 22 and 48%, reductions in the variances of the actual cost and schedule to within 10% of the estimates, and two TSP software teams realizing a net combined savings of \$2.746 million with the conclusion of their first TSP software development projects. These cost savings were six times the cost of AV-8B's and P-3C's investment in training and startup of PSP and TSP.

(U) The successes that NAVAIR's Air 4.0, Research and Engineering Competency, enjoyed helped to create a culture that is both interested in the continued pursuit and advancement of process improvement within its ranks, and desiring to spread process improvement to the larger organization.

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CONTENTS

Acknowledgment	2
Introduction.....	3
Background.....	4
The Software Process Improvement Tool Set	6
Capability Maturity Model (CMM)	6
Capability Maturity Model Integration (CMMI)	7
Earned Value Management System (EVMS).....	7
High Performance Organization (HPO)	7
Personal Software Process (PSP)	7
Team Software Process (TSP).....	8
Team Software Process for Multiple Teams (TSPm)	8
The SPI Journeys of the Early Adopters.....	8
AV-8B Joint System/Software Support Activity	8
E-2C Software Support Activity	12
EA-6B Software Support Activity	13
P-3C Software Support Activity.....	14
TACAIR EW Software Support Team.....	16
F/A-18 SWDTT.....	16
Overall	17
The Future of Process Improvement Within NAVAIR	18
Conclusions.....	21
Recommendations.....	22
Resources.....	23
Within the Navy	23
Outside the Navy.....	23

Appendixes:

A. NAVAIR Software Process Improvement Instructions	A-1
B. NAVAIR Organizational Goals	B-1
C. DOD Criteria for Earned Value Management System Certification.....	C-1
D. Standard CMMI Assessment Method for Process Improvement.....	D-1
E. Code 4.0 Articles and Presentations Related to Software Process Improvement	E-1

References.....	F-1
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Acronyms.....	G-1
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P-3C Software Support Activity
SPIKE Development Team
Tactical Aircraft Electronic Warfare Software Support Activity

INTRODUCTION

This paper is intended to provide an overview of the Software Process Improvement (SPI) efforts of Naval Air Systems Command's (NAVAIR) Air 4.0, Research and Engineering Competency. NAVAIR 4.0 provides life-cycle systems development along with operations and maintenance support for the aircraft and weapons of the U.S. Navy and Marine Corps. NAVAIR 4.0 is distributed across the country: Patuxent River, Maryland; Lakehurst, New Jersey; Orlando, Florida; and China Lake and Point Mugu, California (Figure 1). While there are NAVAIR facilities located in Italy and Japan, this report will focus on the 24 discrete software engineering teams located within the U.S., and specifically on the SPI efforts of the six teams that were early SPI adopters.

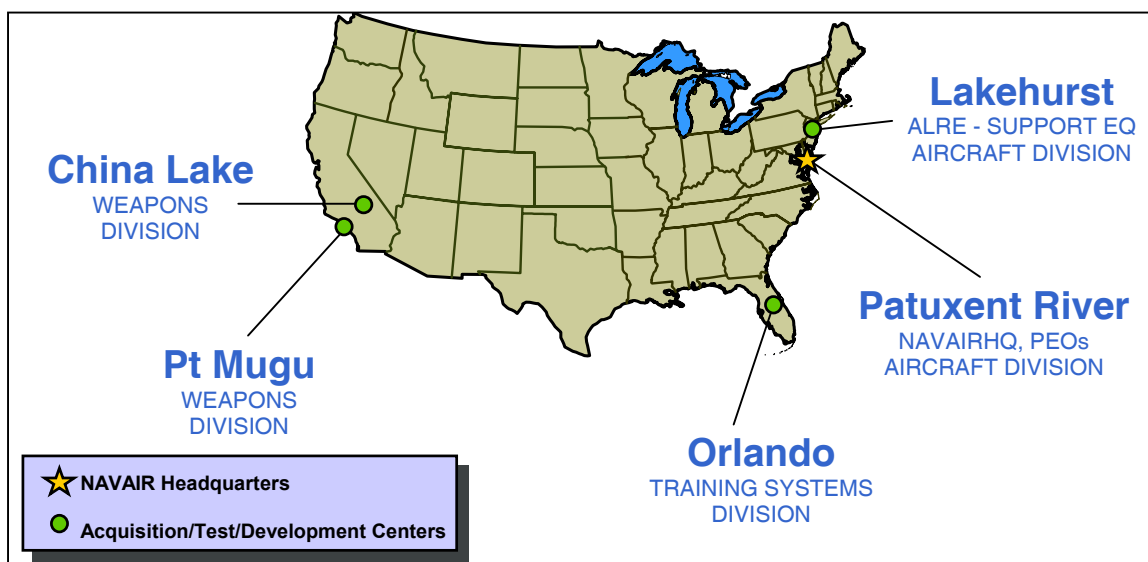


FIGURE 1. The Locations of NAVAIR Facilities Within the U.S.

The early SPI adopters mentioned above were the software development teams within the AV-8B Joint System Support Activity (JSSA); the E-2C, EA-6B, P-3C, and Tactical Aircraft Electronic Warfare (TACAIR EW) Software Support Activities (SSAs); and the F/A-18 Software Development Task Team (SWDTT). These teams ranged in size from less than 10 to more than 70 NAVAIR software engineers and support contractors. They were organized under the Director of the Engineering Division of the Research and Engineering Group, Code 4.0, of NAVAIR Weapons Division (WD).

BACKGROUND

Over the last several decades NAVAIR, the parent organization of Code 4.0, Research and Engineering Group, has experienced tightening budgets, decreasing labor pools (Figure 2), increasing software complexity (Figure 3), and, finally, the demands of the Global War on Terrorism (GWT). Throughout this period, NAVAIR has worked to meet the challenge of accomplishing its mission while procuring the new aircraft necessary to meet its future obligations to the Fleet.

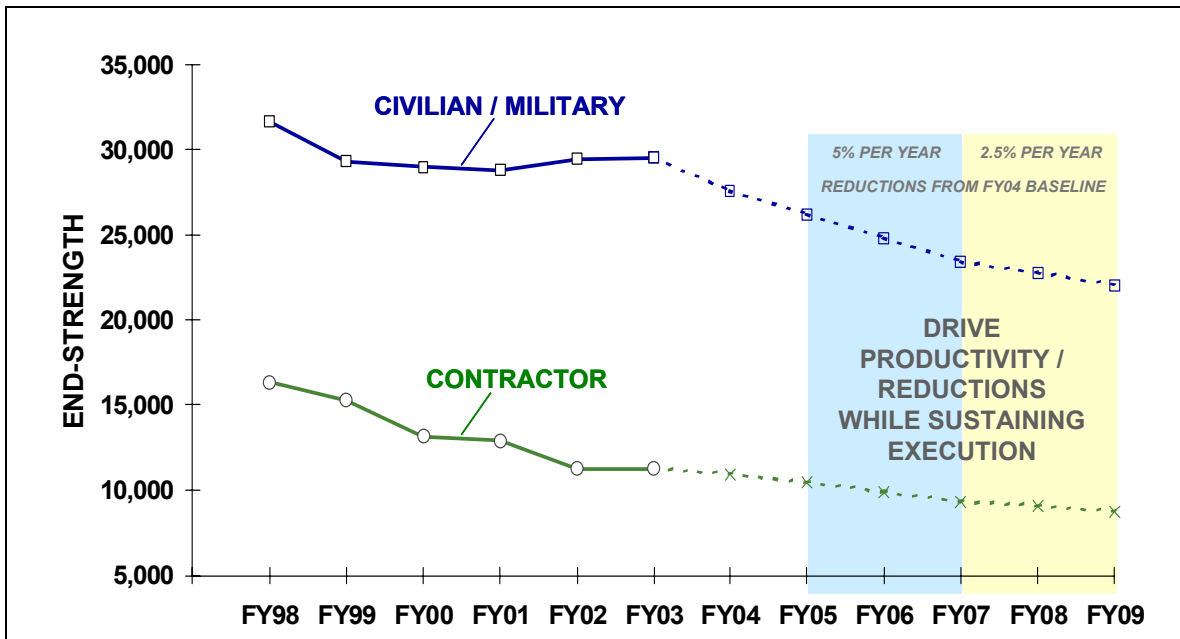


FIGURE 2. Manning History and Forecast.

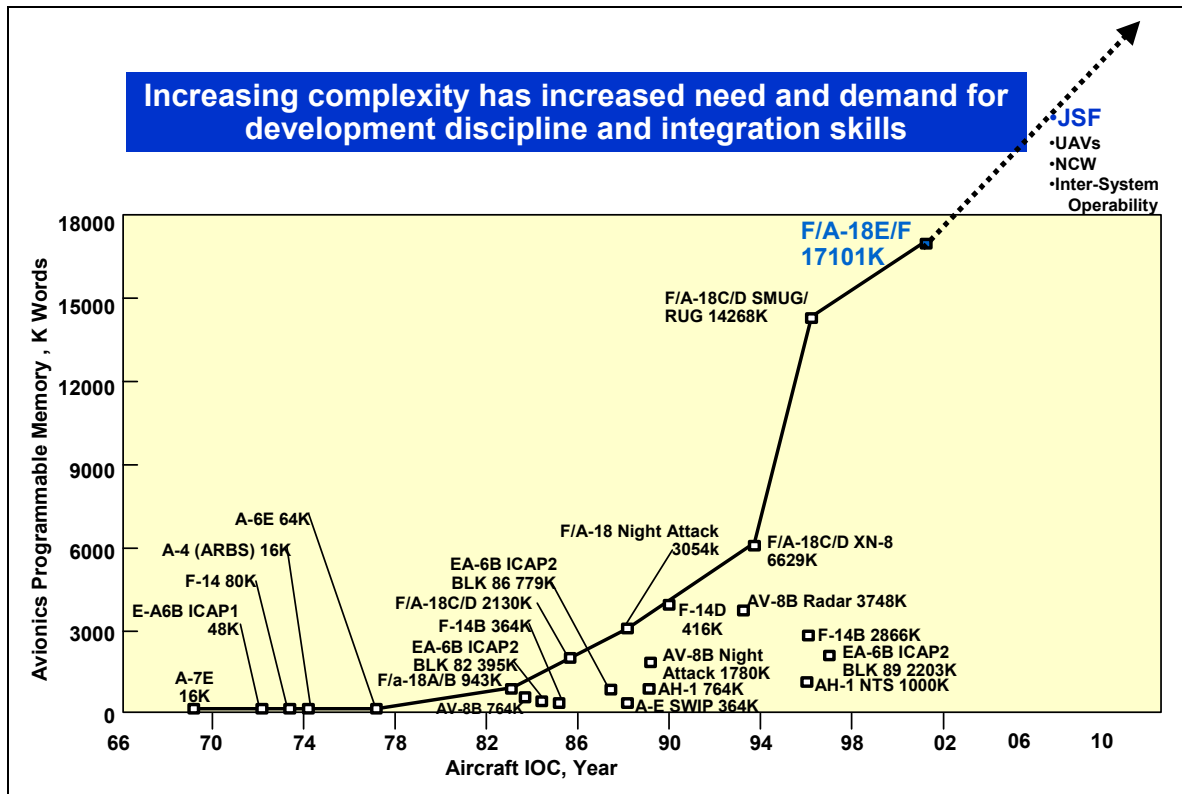


FIGURE 3. Aviation Software Complexity.

To meet this challenge, process improvement efforts were initiated throughout NAVAIR, in all business areas, including administration, contracting, support, and software development. These initiatives began to take shape for Code 4.0 in 1998 when AV-8B joined F/A-18 in the pursuit of process improvement. Between April and September 2002, NAVAIR issued a set of five formal instructions as guidance on process improvement for software acquisition, development, and life cycle maintenance (see Appendix A). One of these instructions, NAVAIRINST 5234.2, was based in part on Code 4.0's research into process improvement tools and techniques (Reference 1, page 9). In December 2002 NAVAIR 4.0's voluntary effort was bolstered by the passage of the U.S. Federal Government statute, Public Law 107-314, the Bob Stump National Defense Authorization Act for Fiscal Year 2003. Section 804 specifies that software acquisition programs must meet the following requirements:

- Shall have a documented process for planning, requirements development and management, project management and oversight, and risk management.
- Shall have a metrics for performance measurement and continual process improvement.

- Shall have a process to ensure adherence to established process, and requirements related to software acquisition.

In this environment, the goals of the SSAs were to improve the maturity of the software development processes, to realize cost savings, and to deliver higher quality products to the Fleet—in essence, to meet the challenges of their missions while at the same time meeting NAVAIR’s stated organizational goals, as stated in 2005 (see Appendix B).

THE SOFTWARE PROCESS IMPROVEMENT TOOL SET

The initial SPI efforts of the individual SSAs were not coordinated across NAVAIR 4.0. Each SSA acted as an independent entity within the overall effort, starting at different times and selecting SPI tool sets specific to the needs of their individual organizations (Table 1).

TABLE 1. The SPI Tool Sets of the NAVAIR Early Adopters.

Organization	Process improvement tools					
	CMM	CMMI	TSP	EVMS	HPO	TSPm
AV-8B	✓		✓	✓	✓	
E-2	✓		✓			✓
EA-6B	✓	✓			✓	
P-3C	✓	✓	✓		✓	✓
TACAIR EW	✓	✓			✓	
F/A-18 SWDTT	✓	✓	✓	✓	✓	

CAPABILITY MATURITY MODEL (CMM)

A Carnegie Mellon University, Software Engineering Institute (SEI) framework for incremental process improvement, CMM consists of best practices that cover the complete product life cycle, starting with defining requirements and continuing on through maintenance of the delivered products. The CMM is broken into five levels of maturity, each with a discrete set of practices that characterize an organization operating at that level. It is a useful tool for appraising organizational maturity and for guiding incremental process improvement efforts. CMM is sometimes used interchangeably with Software-CMM (SW-CMM).

CAPABILITY MATURITY MODEL INTEGRATION (CMMI)

This is SEI's follow-on model, which replaces several process improvement tools, including the CMM. CMM is the baseline for the CMMI, but expanded to include System Engineering (SE) and generalized to accommodate a wider variety of business models. It encourages organizations to focus process improvement efforts based on one or more specific areas of their business, instead of requiring one all-encompassing process improvement effort. In this way, organizations may pursue process improvement in only those areas they deem most urgently in need of process improvement.

EARNED VALUE MANAGEMENT SYSTEM (EVMS)

This is a tool for program management that allows visibility into both technical issues and cost and schedule progress on projects and contracts. Analysis using EVMS can provide an early warning for issues with a project or contract, from as early as the point at which 15% of that effort has been completed. In order to use EVMS, program management must ensure that their effort is fully defined from the beginning, including a bottom-up plan. In this plan, each discrete task will have an associated value that corresponds to a percentage of the total work effort. This will allow measurement of the bottom-up plan for the entire period of performance. The data collected provide a way to show actual performance improvement, and become the basis of modeling predictable performance for future projects. EVMS is one of the CMMI's best practices for project planning.

HIGH PERFORMANCE ORGANIZATION (HPO)

HPO is an organizational improvement plan that is guided by the Diagnostic/Change Model for Building High-Performance Organizations as developed by the Commonwealth Centers for High Performance Organizations (CCHPO). It is commonly referred to as the Diagnostic/Change Model. The work is typically initiated with a workshop ("Teamway") designed to help a group develop the skills required to improve their performance by continually using the Diagnostic/Change Model. Conducted with intact work groups, the 3- to 5-day workshop is tailored to each group's needs, concerns, and issues.

PERSONAL SOFTWARE PROCESS (PSP)

The PSP is a SEI methodology for developing high quality software. It is based on the practices that are characteristic of CMM and CMMI Maturity Level 5 organizations. It uses standards, methods, scripts, measures, and forms to provide a highly structured and disciplined framework for individual software developers to use in their daily

software development efforts. The measurements collected are used to improve the quality of the products developed.

TEAM SOFTWARE PROCESS (TSP)

The TSP is based on the concepts and practices of the PSP and is the methodology through which PSP may be applied to team-based, software development efforts. All software engineers participating in a TSP team are required to be PSP trained. TSP and CMMI are complementary, and they work best when introduced into an organization at the same time (Reference 1, page 5). The data collected from these teams are used to set performance and quality objectives for the organization.

TEAM SOFTWARE PROCESS FOR MULTIPLE TEAMS (TSPm)

TSPm is an SEI prototype methodology derived from the TSP that is intended to facilitate the application of TSP principles in situations where there are multiple TSP teams engaged in developing sub-units of software for a common product.

THE SPI JOURNEYS OF THE EARLY ADOPTERS

AV-8B JOINT SYSTEM/SOFTWARE SUPPORT ACTIVITY

The AV-8B JSSA started its SPI process in 1998. At that time, AV-8B's active project ("Project A"), was estimated to be 9 months behind schedule (a 17.6% schedule overrun) and \$49 million over budget (a 28.3% cost overrun). Determined to address the root causes of this disappointing performance, AV-8B created an independent review team to inspect the Project A software development effort. The team completed the review and recommended that AV-8B pursue process improvement. To focus that pursuit, AV-8B determined that their top-level SPI goals would be to implement EVMS for tracking project cost and schedule, and to implement HPO concepts in order to develop a more mature software development process. The plan also called for obtaining an EVMS certification. The Department of Defense (DOD) criteria for obtaining certification are listed in Appendix C.

AV-8B's progress was swift. EVMS training began in October 1998 and AV-8B's Software Engineering Process Group (SEPGSM) was formed in March 2000. This was followed by TSP training in October 2000 and HPO training in January 2001. By May 2001 AV-8B had been assessed at CMM Level 2 and by October 2001 they received

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their DOD EVMS certification, the second organization in the Federal Government to be certified. In September 2002, AV-8B commissioned a SW-CMM CMM-Based Appraisal for Internal Process Improvement (CBA IPI). The assessment concluded that AV-8B had achieved SEI CMM Level 4. Given a start date of March 2000 for CMM, AV-8B managed to reach CMM Level 4 in 2½ years. (The SEI average for progressing from CMM Level 1 to Level 4 is 5½ years (Reference 2, pages 3-4).)

The AV-8B team attributed their rapid advancement through the CMM levels to the use of the TSP and a culture of process improvement. TSP provides a quickly implemented, flexible process framework. The guidance contained in the SEI Technical Report, *Relating the Team Software Process to the SW-CMM* (Reference 3), helped the AV-8B SEPG focus and prioritize its efforts. The technical report proved a valuable tool in applying process improvement techniques in the most efficient manner, shortening what might otherwise have been a long learning curve. Furthermore, TSP distributed the process improvement responsibilities across the project teams, so that process changes originated from within the development teams. This increased the entire AV-8B team's commitment to those changes. The AV-8B JSSA's Leader, Dwayne Heinsma, added "The recipe for accelerating AV-8B's climb up the software maturity ladder centered around identifying champions and using process discipline as an enabler. These champions included a Personal Software Process/Team Software Process champion leading the software team; an organizational process champion leading the development and the institutionalization of organizational standards; senior managers championing the overall effort and removing roadblocks (establishing both TSP and an Earned Value Management as the standard way of doing business at the JSSA); and, most importantly, an excellent team of software engineers, systems engineers, and product integrity support members that made it all happen."

TSP and EVMS improved AV-8B's cost and schedule performance as well. Once EVMS was put into use, schedule and cost variances were brought down to within 10%; the introduction of TSP brought them even lower (Table 2).

TABLE 2. AV-8B Schedule and Cost Variances Related to EVMS and TSP.

Project	Date	Schedule variance	Cost variance	Used EVMS?	Used TSP?
Project A	At 7/98	17.6% overrun	28.3% overrun	No	No
Project B	Complete 4/02	50.0% overrun	300.0% overrun	No	No
Project C	Complete 5/04	5.0% overrun	8.1% overrun	Yes	No
Project D	As of 7/04	0.5% overrun	1.5% overrun	Yes	Yes
Project E	As of 5/04	1.1% overrun	6.9% overrun	Yes	Yes

AV-8B's excellent record in cost and schedule estimation continues to this day. Figure 4 is an Earned Value Chart for AV-8B's Project F Mission Systems Computer

(MSC) Project Software Development Team. The chart was generated by the same TSP tool that the team uses to enter and track their project plan and performance data. As can be seen in Figure 4, after a short delay at the start, the project is now on track with their original plan.

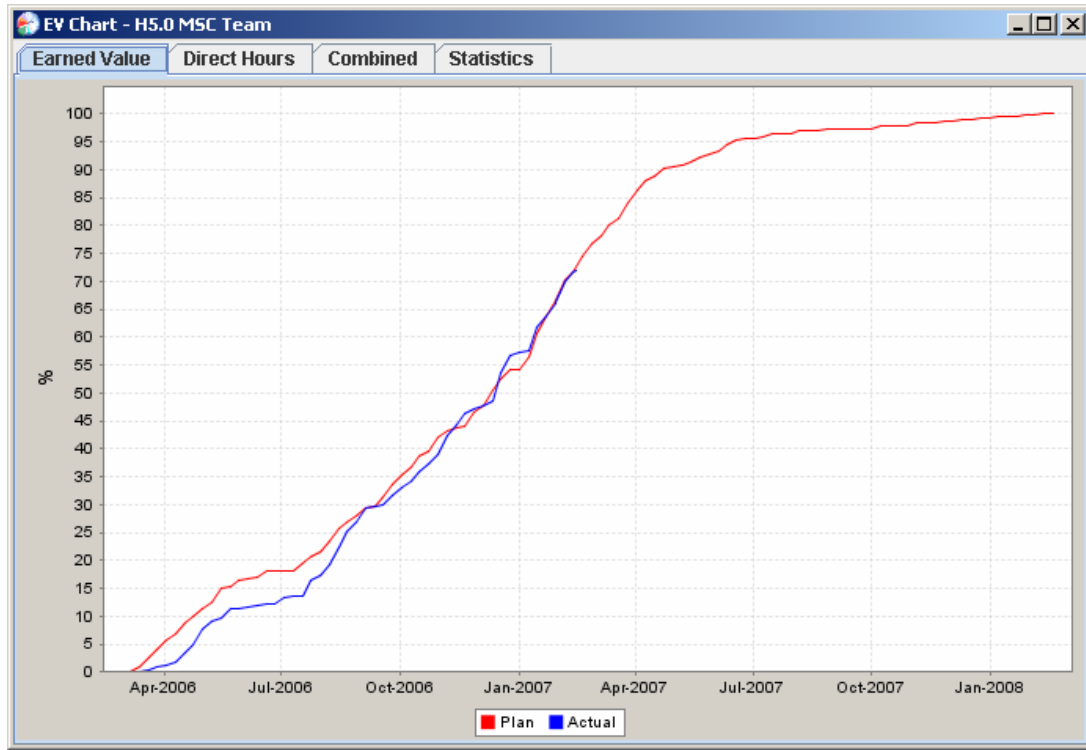


FIGURE 4. Earned Value Chart From the Project F MSC Software Team.

The TSP, while also helping to drive down schedule variances, was instrumental in bringing about a significant reduction in the defect density of the final software products (see Table 3). A 48% decrease in defect density, measured in defects per 1,000 lines of code, occurred between two projects, B and D. The same software engineers were responsible for both development efforts, but Project B used neither EVMS nor TSP, while Project D used both (Table 2). In another illustration of the improvement in quality, a 21% reduction in defect density occurred between Projects C and D. While both of these projects were using EVMS to manage their costs and schedule, only Project D used TSP.

TABLE 3. AV-8B Defect Densities Related to TSP.

S/W development projects	Date completed	S/W defects during V&V	KSLOC	S/W defects per KSLOC	Used TSP?
Project B	4/02	36	32	1.13	No
Project C	5/04	66	89	0.74	No
Project D	7/04	260	443	0.59	Yes
S/W maintenance projects	Date completed	STR defects during system test	STRs resolved	STR defects per 10 STRs resolved	Used TSP?
Project E S/W Cycle 1	3/04	10	88	1.13	Yes
Project G S/W Cycle 1	9/04	2	40	0.50	Yes

To calculate their return on investment (ROI) for TSP, AV-8B compared the defect data from two projects: B and D. Project B was a pre-TSP project that had a defect density of 1.13 defects per KSLOC. Project D was the first TSP project and it had a defect density of 0.59 defects per KSLOC. Table 4 shows the ROI for TSP from savings derived from the avoidance of rework. A hypothetical cost for Project D without TSP is calculated to give an indication of what the cost could have been.

TABLE 4. AV-8B Return on Investment in TSP After One Project.

	Product size (KSLOC)	Defect density (defects/KSLOC)	Number of defects	Cost of addressing defect	Total cost for addressing all defects
Pre-TSP performance baseline					
Project B (pre-TSP)		1.13			
Hypothetical cost of addressing defects for a non-TSP Project D					
Hypothetical Project D cost	443	1.13	501	\$8,330	\$4,169,831
Actual cost of addressing defects for the Project D TSP					
Project D (TSP)	443	0.59	261	\$8,330	\$2,177,169
Cost savings from the avoidance of rework					
Cost savings from reduced defect density					\$1,992,662
AV-8B's cost of TSP training and support					\$225,300
ROI from cost savings from the avoidance of rework					\$1,767,362

AV-8B saved \$1.992 million through the avoidance of rework. Even subtracting AV-8B's expense for initiating TSP, the investment was more than returned.

As this document is being written, AV-8B is expanding from SPI for their software teams to Process Improvement (PI) for the entire organization. They are accomplishing this via a pilot project, Team Process Integration (TPI), based on the TSP that has been modified to apply to teams in disciplines other than software engineering. TPI was developed by SEI and NAVAIR, and AV-8B is working closely with SEI to ensure that the pilot project is a success.

E-2C SOFTWARE SUPPORT ACTIVITY

The E-2C project office in Patuxent, Maryland, initiated its SPI effort in 2000 with an initial goal of “providing the Fleet with quality products that are both affordable and available when they are needed.” E-2C intended to achieve an SEI CMM Level 2 rating over the course of a 6- to 12-month project. After reviewing the available SPI tools, the team adopted TSP. It was decided that the use of TSP would commence with the start of the next major project. During the planning for that project the scope of work proved to be larger than the current work force could handle. In 2002, while searching for a solution to this challenge, E-2C discovered an opportunity.

In 2001, the F-14D SSA at Point Mugu, California, was using SEI CMM and had begun training for (and using) TSP in its final major software release to the Fleet. Although the program was scheduled to be phased out after the completion of that project, F-14D management considered TSP training to be an excellent investment to make in the project engineers. They set the goal of achieving a CMM Level 2 rating and proceeded. E-2C learned that the F-14D program would be closed in mid 2003, and that the project engineers would become available for work elsewhere. The F-14D engineers had the training and disciplined software processes that E-2C was seeking, so E-2C approached F-14D management with the idea of folding those engineers into the E-2C at the conclusion of the F-14D program. The F-14D managers agreed.

E-2C launched its first TSP project in May 2003 and was formally assessed at CMM Level 2 in June. In July 2003 it incorporated the F-14D engineers into E-2C and launched a second TSP project at Point Mugu. After making some progress on the project, E-2C re-launched, replacing TSP with TSPm. E-2C found that TSPm was effective for organizing and managing both large and distributed teams. It was also effective in bringing together groups with different backgrounds, by giving them a common language and process. Table 5 shows the performance of three of E-2C’s early TSP projects.

E-2C is currently transitioning from CMM to CMMI.

TABLE 5. Schedule Performance of Three Early E-2C TSP Projects.

Project name	Planned length, weeks	Actual length, weeks	Schedule variance
SCS-04 ACIS	33	32	3% under
SCS-04 MC	28	38	36% overrun
SCS-05 SIAP Phase I	29	34	17% overrun

EA-6B SOFTWARE SUPPORT ACTIVITY

The EA-6B SSA employs over 200 people in support of the development, enhancement, and maintenance of almost 8 million source lines of code (SLOC). EA-6B began its SPI process in October 2000 with the acquisition of Pragma's processMax® software. A process improvement lead was assigned in May 2001 and a Process Steering Committee was established in September 2001. EA-6B's SPI toolset included the CMM and HPO, but the initial focus was the implementation of an organizational level process via the processMax software tool. Mini-assessments were conducted in May and October 2003 and in February 2004. These preparations paid off when the EA-6B SSA achieved CMM Level 3 in its first official appraisal in September 2004.

One of the most significant payoffs for the EA-6B SSA occurred during the EA-6B ICAP III Block 2 project. The payoff was a substantial reduction in the number of Operational Flight Program (OFP) defects discovered per 100 system test hours. The rate of discovery of defects is a standard NAVAIR product maturity measure used in Operational Test Readiness Reviews (OTRRs). The goal of the EA-6B ICAP III Block 2 project was to have a rate of discovery of no more than 12 defects per 100 hours. However in the last quarter of 2004, EA-6B noted that their OFP defect discovery rate went from the desired rate of 12 to more than 20 per 100 hours. Their ICAP III team reviewed the data and in early 2005 used the results of their analysis to modify their software peer review process to enhance its effectiveness. The changes that the ICAP III team made allowed them to discover and correct a greater number of defects prior to releasing the next OFP Build. The result was a reduction in the rate of discovery to 6 per 100 hours, surpassing their original quality goal.

The EA-6B SSA was also able to deliver software intensive products ahead of schedule. SPI helped the Airborne Electronic Attack (AEA) Unique Planning Component (UPC) project maintain and surpass their planned software development and delivery schedule. Maintaining these delivery commitments was critical to the success of the prime contractor development activities.

A number of other SPI initiatives resulted in cost and schedule savings for the EA-6B Weapon System Support Laboratory (WSSL). When added together, these additional annual savings come to 1,231 labor hours (two-thirds of a work-year). These initiatives include:

- Upgrading the WSSL Discrepancy Reporting (WDR) process to be CMMI compliant and utilizing Lean Six Sigma concepts to reduce work-in-progress. The new process provided web-based access for submission and tracking of WDRs. This resulted in a reduction of manual labor for input/updates from 4 hours per week to 1 hour, an estimated annual savings of 156 hours. Metrics reporting is now automated rather than manual. A new process for testing and closing WDRs reduced work-in-progress by 50% in the first year, an estimated savings in labor of 650 hours per year.
- Documenting and improving the laboratory engineering drawing and simulation Configuration Management (CM) process to be CMMI compliant. The estimated savings in labor was 425 hours per year.

P-3C SOFTWARE SUPPORT ACTIVITY

P-3C began its process improvement initiative in April 2001 with the formation of an HPO leadership team. Their initial goal was to implement HPO concepts within the organization to develop more mature software development processes. P-3C then decided to add the CMMI and the TSP to its tool set. A SEPG was formed in February 2002 and the first TSP launch was conducted in May 2002. In March 2003, after performing a comprehensive gap analysis, the organization transitioned from CMMI to the CMM. While the value of CMMI was recognized, CMM would allow a quicker pace (with an earlier “win” providing encouragement to the team). In May 2004, within 27 months of forming their SEPG, P-3C achieved CMM Level 4. As with AV-8B, P-3C achieved this in less than half of the 5½ years normally expected (Reference 2, pages 3-4).

In August 2004 P-3C performed a CMMI gap analysis and transitioned from CMM back to the CMMI. In October 2005, 17 months after achieving CMM Level 4, P-3C completed a Standard CMMI Assessment Method for Process Improvement (SCAMPI)SM B. While a SCAMPI B does not result in an official CMMI rating, the results of the SCAMPI B indicated that P-3C was operating close to CMMI-Software Level 5. Appendix D contains a definition and general description of the different types of SCAMPIs. One interesting finding from the P-3C SCAMPI B Appraisal Findings Report was that “TSP/PSP implementation has provided a rich data source upon which to build, compare, and begin statistical management of selected processes” (Reference 4).

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P-3C had progressed rapidly through the CMM levels, but what sort of return on investment did they see for TSP? Assuming all other things to be equal, it is useful to focus on the savings realized through the increased quality that TSP brings (i.e., savings from the avoidance of rework). To do that, two projects were compared: a P-3C non-TSP project (for the performance baseline) and P-3C's first TSP project. Table 6 lists some basic performance data for these projects. It includes a hypothetical cost for the TSP project based on the non-TSP defect density. This will give an indication of what it might have cost the project to repair defects in "Unit" test had it not been a TSP project. In this example, P-3C refers to defects as Software Problem Reports (SPRs).

TABLE 6. P-3C Performance Data Comparison for Non-TSP and TSP Projects.

	KSLOC added/changed	Defect density/ KSLOC	Number of SPRs	Average SPR fix cost	Total SPR fix cost
Pre-TSP performance baseline					
Non-TSP Project	27.8	4.6	128	\$8,432	\$1,078,284
Hypothetical cost of addressing defects had TSP project not used TSP					
Hypothetical Project	38.3	4.6	176	\$8,432	\$1,484,032
Actual cost of addressing defects for the TSP project					
TSP Project	38.3	0.6	23	\$8,432	\$193,936
Cost savings from the avoidance of rework					
Cost savings from reduced defect density					\$1,290,096
P-3C cost of TSP training and support					\$311,247
ROI from cost savings from the avoidance of rework					\$978,849

The number of SPRs generated during Unit testing of the TSP project was seven times lower than the non-TSP project because the developers were able to identify defects early in the development process, rather than having to "test" them out. As a result, the total cost of removing the Unit test defects was significantly lower than the non-TSP project, even though that project was actually larger in terms of total KSLOC.

When the Unit test defect removal cost of the TSP project is compared to what that cost might have been had TSP not been used, the savings by avoiding rework were nearly \$1.3 million. P-3C invested \$311,247 into the training, setup, and support for TSP. Subtracting those costs from the savings gives an ROI of \$978,849. P-3C's investment in TSP was more than returned with their first TSP project.

TACAIR EW SOFTWARE SUPPORT TEAM

TACAIR SSA provides post-deployment, mission critical software and systems engineering, integration, and testing for TACAIR Strike and Assault aircraft. TACAIR SSA began pursuing SPI in March 1999. A process guide was developed and published in October 2000 and several HPO sessions were held. In August 2002 TACAIR SSA held a formal assessment and, due to some minor deficiencies in the area of software quality assurance, just missed obtaining a CMM Level 2 rating. Applying the lessons from that assessment, by August 2004 TACAIR SSA was assessed at CMM Level 3. In 2005 it was using the results of a SCAMPI C assessment to help formulate a transition from CMM to CMMI.

F/A-18 SWDTT

The F/A-18 SWDTT is a 70 member sub-team of the F/A-18 Advanced Weapons Lab (AWL). It was among the earliest adopters of process improvement as a way to reduce cost and improve quality. F/A-18 SWDTT has pursued SPI since the early 1990s and in December 1997 achieved a CMM Level 3 rating. In November 2000 there was a setback when the SPI lead left during a heavy turnover in personnel (104 personnel within 1½ years). When the SPI Lead position was filled in November 2001, F/A-18 SWDTT realized that any institutionalization of its process improvement had been lost. The decision was made to reorganize and restart the SPI initiative. F/A-18 SWDTT developed a plan based on the results of a CBA IPI assessment conducted in April 2003. As part of that plan, TSP was selected for use within the team and a TSP launch was conducted. F/A-18 SWDTT improved its time tracking tools and established a web site to provide information and resources to support team process improvement. F/A-18 SWDTT also generated a “Five Step Model” for the organization (Reference 5):

1. Focus on familiarization, re-education, and training.
 - Understand that these need to be continuous.
 - Update and present training/orientation packages.
2. Recognize process compliance.
 - Observe: communicate what has been observed.
 - Recognize: brief team members on metrics that are gathered and used.
 - Make it cultural: talk about it.
3. Complete a Self-Assessment and Gap Analysis.
 - “Health check” for process.
 - Next steps.
4. Translate the process changes into something meaningful to the engineering staff.
 - Previous process changes had left the engineering staff feeling uninvolved.
 - Time saving.
 - Effort saving.

5. Collect and use your metrics.
 - Improve cost estimates.
 - Improve schedules.
 - Improve product quality.
 - “Steps” must be concurrent.
 - “Steps” must be sustained.
 - Process Improvement should be a project.

F/A-18 SWDTT conducted a SCAMPI B in October 2004 and used the results of that assessment to prepare for a SCAMPI A. The effort was successful and in March 2005, F/A-18 SWDTT was assessed at CMM Level 5, the first in the Navy.

Following the Level 5 assessment, F/A-18 SWDTT set new goals that included assisting all the appropriate AWL teams in the entire F/A-18 AWL to achieve CMMI Level 3 maturity. If successful, this would encompass the development, enhancement, and maintenance of over 10 million SLOC.

OVERALL

Overall, the SSAs made steady SPI progress and delivered significant achievements (see Figure 5). It is important to note again the rapid progression of several of the SSAs through the CMM levels. Using TSP, AV-8B and P-3C were able to achieve CMM Level 4 in less than 3 years: March 2000 to September 2003 for AV-8B, and February 2002 to May 2004 for P-3C. The SEI average for progressing from CMM Level 1 to Level 4 is 5½ years (Reference 2). The colored zones in Figure 5 represent recommended CMM goals that were set in the February 1999 NAVAIR Team Software Strategic Plan. The lines connecting the milestones are there only to group certain information.

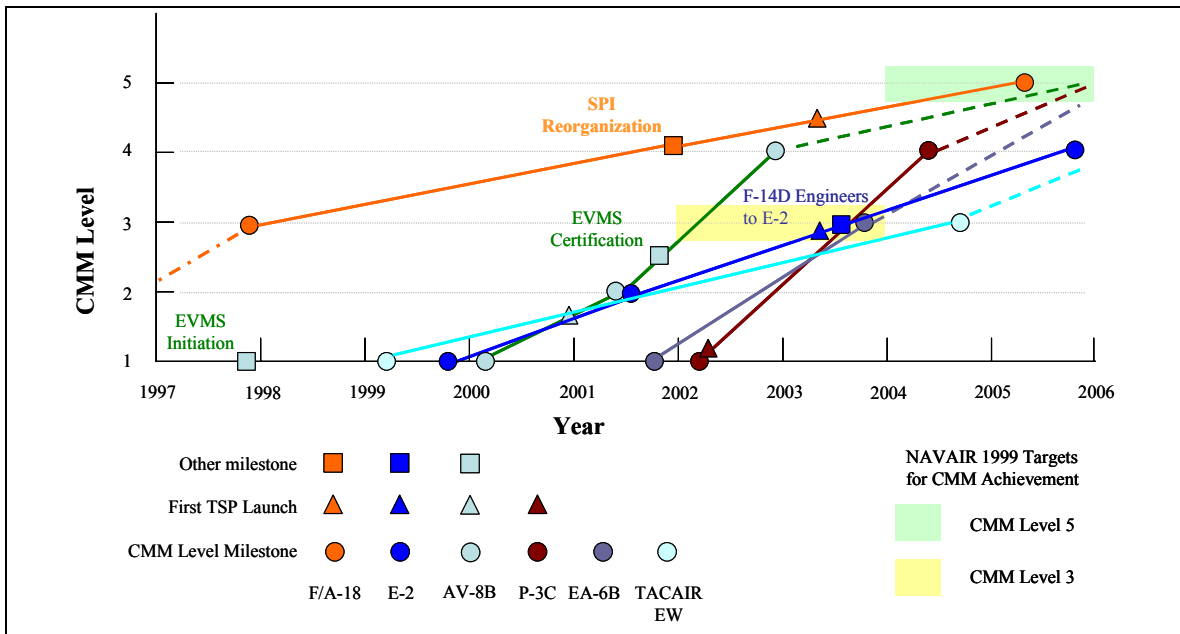


FIGURE 5. Time Line of SAA CMM Progress and Related Milestones.

THE FUTURE OF PROCESS IMPROVEMENT WITHIN NAVAIR

NAVAIR 4.0's SPI efforts have been successful in developing mature organizations and in obtaining an excellent ROI. The early SPI adopters are meeting their missions, producing higher quality products, and generating significant cost savings. Their success stories have inspired other SSAs within NAVAIR 4.0 to adopt SPI. Fifteen of the 18 SSAs that were not among the early adopters of SPI are now pursuing SPI in some form. Figure 6 is an Earned Value Chart generated by the TSP tool of the Anti-Radiation Missile (ARM) UPC 0.4 Software Development Team documenting that these new adopters are experiencing the same performance improvement as the early adopters.

SPIKE Program Manager Mr. Steven D. Felix said of their recent PI efforts "... TSP was a major contributor to the success of our project. Most processes assume large teams and huge budgets, and because of this are of no value to small projects like SPIKE. Never have I seen a process that was so scalable that it was useful to a team as small as SPIKE. The metrics collected are tuned for our project. When a metric did not show any value, we could stop collecting it and figure out what to collect that did make sense. TSP has been so successful that the SPIKE project has adapted it to our hardware design process."

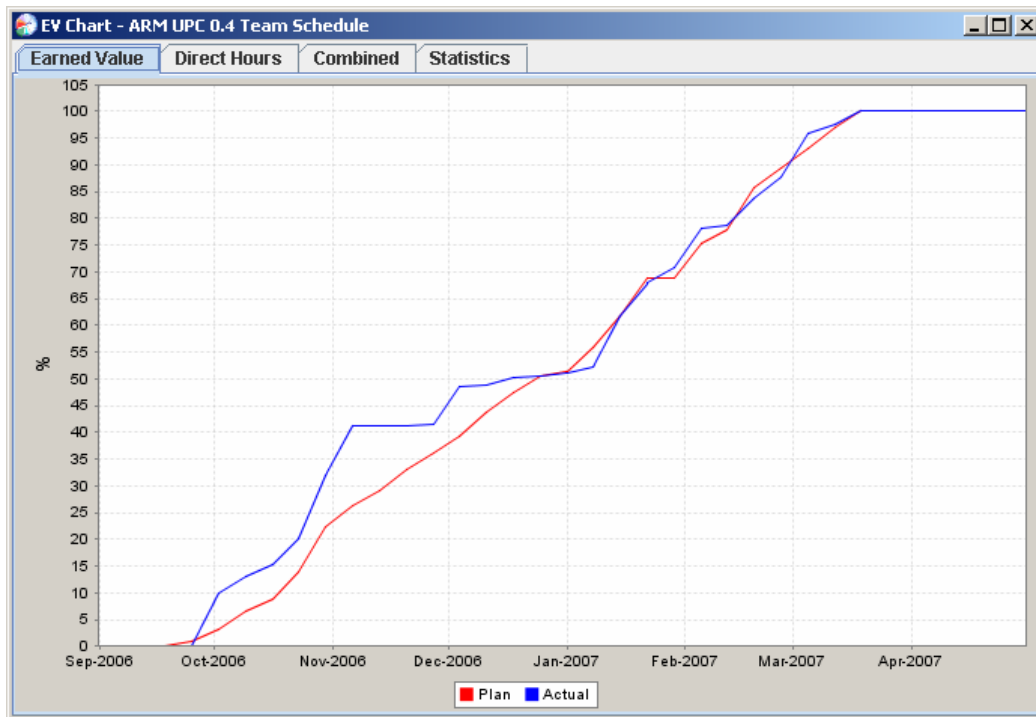


FIGURE 6. Earned Value Chart of the ARM UPC 0.4 Software Team.

As these new adopters continue to make progress with SPI, the recurring savings will allow NAVAIR to redirect even more funds to the Fleet for procurement of critical needs, including new aircraft.

As part of the effort to promote process improvement amongst the SSAs, NAVAIR 4.0 created the NAVAIR Software/Systems Support Center (NSSC), an organization tasked with providing assistance and guidance with model-based and process-based performance improvement. In pursuit of this mission, the NSSC:

- Developed an internal appraisal method based on the SEI Appraisal Requirements for CMMI (ARC) document to baseline SPI efforts across NAVAIR.
- Works to expand the number of SSAs within NAVAIR 4.0 that are pursuing SPI.
- Sponsors the NAVAIR Software Process Improvement Community of Practice (SPI CoP) quarterly conferences. Representatives from all NAVAIR 4.0 SEPGs attend these conferences. SPI CoPs are a forum for exchanging SPI histories, best practices, techniques, tools, and lessons learned.
- Sponsors the NAVAIR TSP CoP monthly meetings. TSP coaches and instructors who support NAVAIR 4.0's TSP teams attend these meetings. They coordinate future events, share best practices, and keep each other aware of the status of ongoing efforts.

- Works with the SEI to introduce and pilot TPI projects, a modified TSP for acquisition and SE process improvement. This has resulted in the creation of new courses, including the 2-day SE focused course, Team Member Training.
- Provides SEI-authorized training in CMMI and coaching in PSP/TSP/TPI.

The charter of the NSSC also calls for reinforcing and aligning NAVAIR 4.0's SPI initiatives with NAVAIR's general process improvement initiatives, such as the AIRSpeed lean six-sigma project. While the efforts of NAVAIR AIRSpeed do not fall under the scope of this document, AIRSpeed is described here as an important part of the overall process improvement environment. NAVAIR AIRSpeed lean six-sigma was selected as the Naval Aviation Enterprise (NAE)-wide mechanism for reducing costs and improving productivity and customer satisfaction. AIRSpeed utilizes a structured, problem solving methodology called DMAIC (Define, Measure, Analyze, Improve, Control), widely used in business. DMAIC leads project teams through the logical steps from problem definition to problem resolution. Each phase has a specific set of requirements to be met before moving on to the next phase of the project. A summary of steps are as follows:

- Define the problem.
- Measure the baseline performance of the process being transformed.
- Analyze the process to determine a prioritized list of root causes for any process performance shortfalls.
- Improve the target process by designing innovative solutions to resolve the identified root causes.
- Control the process to ensure that the improved process continues to deliver the expected results.

AIRSpeed solicits recommendations on process change from all NAVAIR personnel and contractors. The responsibility for following up on those recommendations rests with specially trained personnel (Black Belts).

As part of the effort to institutionalize lean six-sigma, NAVAIR organized and held an annual NAVAIR lean six-sigma symposium. The Navy, looking for a way to spread lean six-sigma throughout the organization, saw the success of NAVAIR's event and had NAVAIR establish the first Navy-wide, lean six-sigma symposium in May 2007.

Not content with just experiencing the tangible advantages of process improvement, NAVAIR 4.0 is devoted to spreading SPI throughout the Navy, the Federal Government, industry, and beyond. NAVAIR 4.0 is a co-sponsor of DOD's *Crosstalk* magazine; has been the sponsor of various conferences, workshops, and panel discussions; and has published numerous articles on SPI (see Appendix E). NAVAIR 4.0 personnel participate in the international TSP Users Group (TUG) conferences, with one NAVAIR employee holding the office of TUG Conference Chairman for 2 years; the annual National Defense

Industrial Association (NDIA) CMMI-User's Conferences; and the annual SEI SEPG Conferences. This effort on behalf of SPI has been noticed by the wider community, which gave a NAVAIR employee the 2007 SEI Member Representative award.

CONCLUSIONS

NAVAIR 4.0 had recognized the need for and was pursuing SPI even before the U.S. Government entered into the issue with Public Law 107-314. NAVAIR 4.0's dedicated interest in SPI resulted in:

- The first CMM Level 5 rating in the Navy.
- The second EVMS certification in the Federal Government.
- Two teams achieving CMM Level 4 in less than half the normal time.
- Defect density reductions ranging from 22 to 48%.
- Cost and schedule variances reduced to within 10%.

SPI also paid impressive ROIs. AV-8B and P-3C invested a combined total of \$536,000 into the adoption of TSP and saw a combined gross savings from their first TSP efforts (through the avoidance of rework) of an estimated \$3.283 million. This gave a net ROI of approximately \$2.746 million. EA-6B, using the WDR process and lean six sigma concepts, saved at least \$116,000.

The successes that NAVAIR 4.0 has enjoyed from SPI and its culture of process improvement have helped to ensure the continued pursuit of and advancement of SPI within the organization. A belief in the real value of SPI to the Navy and to the Government has created a NAVAIR 4.0-wide software development community with a desire to spread SPI outside its own ranks. Government bureaucracies are wary of change, and many will actively resist change unless they are provided with concrete examples of its advantages. This resistance often begins with the individual workers and extends up through middle management. When a Government organization recognizes the need for change, and the personnel throughout that organization actively seek it out, a fundamental shift in paradigms has taken place. NAVAIR 4.0 demonstrated this dramatic change in thinking through the widespread adoption and institutionalization of CMMI and TSP. It is an operational example of the concrete advantages of pursuing SPI: higher quality products, at lower cost, while maintaining the mission.

In January 2003, Darrell Maxwell, at that time Department Head of the NAVAIR Systems Engineering Department, made the following statement after reviewing NAVAIR 4.0's organization and the strides that had been made in just 3½ years of SPI efforts: "In February 1999 we at NAVAIR set out to make notable achievements in software process improvement across the organization. It was just good business. It is

now January 2003, and we have not only met our goals, but in some cases achieved even more than we planned.”

RECOMMENDATIONS

A complete discussion of the introduction of process improvement into an organization is not within the scope of this document. However there are some basic concepts and resources that will help. Process improvement can be a difficult undertakings, and if it is not pursued in a systematic fashion, it will be much more difficult. SEI identified eight key concepts for introducing process improvement into an organization*, with the focus on introducing CMMI. The concepts are summarized here.

1. Secure Sponsorship and Funding. First, ensure that the process improvement effort has both a senior management sponsor and funding.
2. Take Core Training. Understand the basic concepts of the tools and methodologies that will be used in the process improvement effort.
3. Prepare the Organization for Change. Treat process improvement as a project. Establish business reasons and goals for the effort. Create a case and rationale for undertaking this change. Identify the expected costs and benefits for everyone. Plan for and manage the human side of change.
4. Form an Engineering Process Group (EPG). The EPG should coordinate the process improvement activities across the organization.
5. Know Where You Are. Survey the organization and compare their processes to those of the tools and methodologies that will be used in the process improvement effort. This will serve as a baseline for the effort.
6. Know Where You Are Going. Determine the overall process improvement goals for the organization. Prioritize the areas to be addressed and then, using the baseline for the organization as the starting place, plan the path to achieve those goals. Track the organization’s progress against the plan.
7. Communicate and Coordinate. Promote and practice honest and open communication. The plan should be shared with all affected parties. Comments and concerns should be taken seriously.
8. Track Your Progress. Monitor the progress of the organization through the plan, making adjustments as needed.

*<http://www.sei.cmu.edu/cmmi/adoption/cmmi-start.html>, 2007.

RESOURCES

Numerous resources are available both inside and outside of the Navy to assist process improvement efforts. Following is a partial list of organizations and associations that may be of interest.

Within the Navy

NAVAIR AIRSpeed. The NAVAIR mechanism for reducing costs and improving productivity and customer satisfaction. AIRSpeed utilizes the DMAIC (Define, Measure, Analyze, Improve, Control) structured problem solving method. The official AIRSpeed web site is <http://www.navair.navy.mil/navairairspeed/>.

NAVAIR Systems/Software Support Center. A resource for support with the introduction and maintenance of process improvement. NSSC is available to directly support CMMI, PSP, TSP, and TPI. NSSC contact for assistance: 760-939-6226 (DSN 437-6226). The home code for this organization is NAVAIR Code 414300D.

People, Process, and Product Resource (P3R) Group. A resource for personnel and organizational development and the introduction and management of process improvement. P3R is an enterprise team sponsored by NAVAIR Code 4.1.

The Department of the Navy Chief Information Officer (DoN CIO). A resource for information and guidance on the requirements associated with process improvement initiatives within the Navy and Federal Government, as well as links to resources for process improvement tools and methodologies. The DoN CIO web site is <http://www.doncio.navy.mil>.

Outside the Navy

Software Engineering Institute, Carnegie Mellon University. SEI is a Government-funded research center. Their focus is on software process improvement, security, performance measurement, architecture, acquisition, and other important aspects of the software industry. The SEI web site is <http://www.sei.cmu.edu/>.

Institute of Electrical and Electronics Engineers (IEEE). IEEE, an international professional association, is a leader in the advancement of technology. The IEEE web site is <http://www.ieee.org/portal/site>.

Armed Forces Communications and Electronics Association (AFCEA). The focus of this organization is Global Security, but it does include process improvement

resources. AFCEA brings together professionals from Government agencies, industry, and the military, providing an excellent opportunity to network with other professionals working on process improvement. The AFCEA web site is <http://www.afcea.org/>.

National Defense Industrial Association. NDIA is a defense industry association and the industry sponsor of CMMI. It advocates advanced technology and superior training and support for the Armed Forces and Emergency Services. The NDIA web site is <http://ndia.org/>.

Appendix A

NAVAIR SOFTWARE PROCESS IMPROVEMENT INSTRUCTIONS

In 2002, NAVAIR issued a set of five instructions on software acquisition and development.

NAVAIRINST 5234.1

Policy on Software Evaluations for Naval Air Systems Command, dated 30 September 2002. The goal of this instruction was “To Promulgate policy for selecting software prime contractors and subcontractors prior to awarding software intensive systems acquisition contracts within the Naval Air Systems Command.”

NAVAIRINST 5234.2

Requirements for Process Improvement Actions for Naval Air Systems Command Software Acquisition, Development, and Life-Cycle Support, dated 29 May 2002. The goal of this instruction was “To Promulgate requirements, responsibilities, and guidance for improving cost, schedule, and technical performance of Naval Air Systems Command products and services for systems software acquisition, development, and life cycle support.” The instruction was based, in part, on the research of Mr. Jeff Schwalb, of the Software Resources Team, a member of the Business Process Reengineering team (Reference 1, page 9).

NAVAIRINST 5234.3

Establishment of the System Leadership Council and the Software Leadership Team, dated 17 April 2002. The goal of this instruction was “To establish the System Leadership Council and the Software Leadership Team as the principals for leadership direction of software systems acquisition, development, and maintenance improvements within the Naval Air Systems Command.”

NAVAIRINST 5234.4

Independent Expert Program Reviews for Software Intensive Programs, dated 21 June 2002. The goal of this instruction was “To implement the requirements of paragraph C5.2.3.5.6.3 of reference (a) and to provide guidelines for conducting

Independent Expert Program Reviews (IEPRs) within the Naval Air Systems Command.” Reference (a) was the Department of Defense Regulation DOD 5000.2-R, *Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs.*”

NAVAIRINST 5234.5

Naval Air Systems Command Metrics for Software Intensive Programs, dated 30 September 2002. The goal of this instruction was “To establish a basic set of software metrics for managing performance (financial, customer value, and quality) in acquiring, developing, and maintaining software intensive systems.”

Appendix B

NAVAIR ORGANIZATIONAL GOALS

In 2005, NAVAIR's Organizational Goals were stated on the NAVAIR web site.

1. To Balance Current and Future Readiness. We need to ensure that we provide our Naval aviators with the right products to fight the Global War on Terrorism and other future conflicts.
2. To Reduce Our Costs of Doing Business. We need to pursue actual cost reductions, not so-called "savings" or "avoidance." We need to return resources to recapitalize our Fleet for the future. We must continue to introduce best business practices and to remove any barriers to getting our job done.
3. To Improve Agility. It is essential that we make rapid decisions in support of emerging Fleet requirements in order to continue to provide value to the nation. We must reinvigorate a solid chain of command that values responsibility and accountability in its leadership.
4. To Ensure Alignment. We have come a long way with aligning ourselves internally. Now we must ensure that we are fully aligned, internally and externally, with the Chief of Naval Operation's (CNO) transformation initiatives.
5. To Implement Fleet-Driven Metrics. Single Fleet-driven metrics will ensure that we directly contribute to the Naval Aviation Enterprise.

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Appendix C

DOD CRITERIA FOR EARNED VALUE MANAGEMENT SYSTEM CERTIFICATION

ORGANIZATION

- Define contract work using work breakdown structure.
- Identify organizational responsibilities to include sub-contractors.
- Integrate planning, scheduling, budgeting, work authorization, and cost accumulation.
- Identify overhead control responsibilities.
- Measure performance by Work Breakdown Structure (WBS) and organizational breakdown.

PLANNING AND BUDGETING

- Schedule work showing task inter-dependencies.
- Identify physical products, milestones, and technical performance progress metrics.
- Establish and maintain a performance measurement baseline.
- Establish work budgets.
- Establish work and planning packages.
- Reconcile all work/planning package budgets within a control account with that control account's budget.
- Identify and control the level of effort (LOE).
- Identify overhead budgets.
- Identify Management Reserves (MR) and undistributed budgets.
- Reconcile the project cost goal with internal budgets and MR.

ACCOUNTING

- Record direct costs consistent with work budgets.
- Summarize direct costs without allocation to two or more WBSs.
- Summarize direct costs without allocation to two or more organization elements.
- Record all indirect costs.
- Identify unit/equivalent unit or lot costs, when needed.
- Provide full accountability, performance measurement, and accurate cost accumulation.

ANALYSIS AND MANAGEMENT REPORTS

- At least monthly, provide management with information on planned/accomplished work and costs.
- At least monthly, identify direct cost/schedule variances.
- Identify indirect cost variances as needed.
- Summarize variances by WBS and/or organizational element.
- Implement actions based upon earned value (EV) information.
- Develop estimates of costs at completion.

REVISIONS AND DATA MAINTENANCE

- Timely incorporate changes.
- Control internal re-planning.
- Control retroactive changes.
- Change the budget only when authorized.
- Document changes to the performance measurement baseline.

Appendix D

STANDARD CMMI ASSESSMENT METHOD FOR PROCESS IMPROVEMENT

SCAMPI A

The following description of the purpose and benefits of a SCAMPI A is quoted from *Standard CMMI_{SM} Appraisal Method for Process Improvement (SCAMPI_{SM})*, *Version 1.1: Method Definition Document* (Reference 6, pages 1-6).

“The Standard CMMI Appraisal Method for Process Improvement (SCAMPI) is designed to provide benchmark quality ratings relative to Capability Maturity Model Integration (CMMI) models. It is applicable to a wide range of appraisal usage modes, including both internal process improvement and external capability determinations. SCAMPI satisfies all of the Appraisal Requirements for CMMI (ARC) requirements for a Class A appraisal method and can support the conduct of ISO/IEC [International Organization for Standardization / International Electrotechnical Commission] 15504 assessments.”

“SCAMPI V1.1 enables a sponsor to

- gain insight into an organization’s engineering capability by identifying the strengths and weaknesses of its current processes
- relate these strengths and weaknesses to the CMMI model
- prioritize improvement plans
- focus on improvements (correct weaknesses that generate risks) that are most beneficial to the organization given its current level of organizational maturity or process capabilities
- derive capability level ratings as well as a maturity level rating
- identify development/acquisition risks relative to capability/maturity determinations”

“As a Class A appraisal method, SCAMPI is an appropriate tool for benchmarking. Sponsors who want to compare an organization’s process improvement achievements with other organizations in the industry may have a maturity level determined as part of the appraisal process.”

Types of SCAMPIs

The following general description of the three types of SCAMPIs was taken from *Handbook for Conducting Standard CMMI Appraisal Method for Process Improvement (SCAMPI) B and C Appraisals, Version 1.1* (Reference 7, page 4). Only SCAMPI A will result in a formal CMMI rating. SCAMPI B and C are used to guide an organization along the road towards preparing to conduct SCAMPI A.

“The *SCAMPI family architecture* differentiates three classes of methods by identifying the primary focus of SCAMPI A, B, and C as “institutionalization,” “deployment,” and “approach,” respectively. The SCAMPI A method has rigorous standards for detailed data collection, and for identification and coverage of the organizational unit. The SCAMPI B method retains some of the requirements for detailed data collection, but provides relaxed standards for sampling the organization. The SCAMPI C method has relaxed standards relating to evidence of usage. These methods can form building blocks for a progression of appraisals—for example, starting with a SCAMPI C reviewing the process descriptions, then a SCAMPI B investigating their deployment to projects, finally leading to a formal benchmarking event focused on institutionalization of the practices across the organization.”

Appendix E

CODE 4.0 ARTICLES AND PRESENTATIONS RELATED TO SOFTWARE PROCESS IMPROVEMENT

1. "AV-8B's Experience Using the TSP to Accelerate SW-CMM Adoption," *Crosstalk*, September 2002
2. "AV-8B JSSA Team Soars to Level 4," NAVAIR press release, January 2003.
3. "Team Software Process for Maintenance Projects," *Software Engineering Process Group Conference*, Boston, Massachusetts, February 2003.
4. "Accelerating SW-CMM Progress Using the TSP," *Software Engineering Process Group Conference*, Boston, Massachusetts, February 2003.
5. "CMM® + PSP/TSPSM → CMMI®," *Software Technology Conference*, Salt Lake City, Utah, April 2003.
6. "Team Software Process for Maintenance Projects," *Software Technology Conference*, Salt Lake City, Utah, April 2003.
7. "Team Software Process: A Practitioner's Checklist," *TSP User's Group Conference*, Pittsburgh, Pennsylvania, September 2003.
8. "Team Software Process for Maintenance Projects," *TSP User's Group Conference*, Pittsburgh, Pennsylvania, September 2003.
9. "The AV-8B Team Learns Synergy of EVM and TSP Accelerates Software Process Improvement," *Crosstalk*, January 2004.
10. "AVJMPS Project Summary and Lessons Learned," *Software Engineering Process Group Conference*, Orlando, Florida, March 2004.
11. "A Life-Cycle for Corrective Maintenance TSP Projects," *Software Engineering Process Group Conference*, Orlando, Florida, March 2004.
12. "Team Software Process: A Practitioner's Checklist," *System/Software Technology Conference*, Salt Lake City, Utah, April 2004.
13. "AVJMPS Project Summary and Lessons Learned," *System/Software Technology Conference*, Salt Lake City, Utah, April 2004.

14. "Tools And Techniques For Making Your TSP Team More Effective," *TSP User's Group Conference*, Pittsburgh, Pennsylvania, September 2004.
15. "Lessons Learned," *SEPG User's Conference*, Seattle, Washington, March 2005.
16. "A TSP Software Maintenance Life Cycle," *Crosstalk*, March 2005.
17. "Process Improvement at NAVAIR using Capability Maturity Models and TSP," *Software Engineering Process Group Conference*, Nashville, Tennessee, March 2006.
18. "Process Improvement at NAVAIR using TSP and CMM," *Team Software Process Symposium*, San Diego, California, September 2006.
19. "NAVAIR Lamp Model – A Coach's Aid in Helping Teams Apply TSP," *Team Software Process Symposium*, San Diego, California, September 2006.
20. "Interdisciplinary Team Project Management Using TSP Concepts," *Team Software Process Symposium*, San Diego, California, September 2006; and *NDIA Systems Engineering Conference*, San Diego, California, October 2006.
21. "NAVAIR TSP Experience Using the Excel Workbook and Team Dashboard," *Systems and Software Technology Conference*, Salt Lake City, Utah, May 2006; and *Team Software Process Symposium*, San Diego, California, September 2006.
22. "How Applying the Team Software Process and Personal Software Process Can Increase Software Supportability," *NDIA Systems Engineering Conference*, San Diego, California, October 2006.

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1. Software Engineering Institute. *Case Study: Accelerating Process Improvement by Integrating the TSP and CMMI*, by Daniel S. Wall, James McHale, and Marsha Pomeroy-Huff. Pittsburgh, Pennsylvania, Carnegie Mellon University, SEI, 2005. (CMU/SEI-SR-012, report UNCLASSIFIED.)
2. ———. *Case Study: Accelerating Process Improvement by Integrating the TSP and CMMI*, by Daniel S. Wall, James McHale, and Marsha Pomeroy-Huff. Pittsburgh, Pennsylvania, Carnegie Mellon University, SEI, 2007. (CMU/SEI-2007-TR-013, report UNCLASSIFIED.)
3. ———. *Relating the Team Software Process to the SW-CMM*, by Noopur Davis and Jim McHale. Pittsburgh, Pennsylvania, Carnegie Mellon University, SEI, 2002. (CMU/SEI-2002-TR-008, report UNCLASSIFIED.)
4. Naval Air Systems Command. *SCAMPISM B Appraisal Findings*, by P-3C Software Support, Multi Mission Patrol, Mission Area Team. Naval Air Station Patuxent River, Maryland, NAVAIR, 14 November 14 2005. (Report UNCLASSIFIED.)
5. Naval Air Warfare Center Weapons Division. *F/A-18 Software Development Task Team (SWDTT) Lessons Learned on Achieving a CMM Level 5*, by Sharon Juarez. China Lake, California, NAWCWD, 2006. (Presentation UNCLASSIFIED.)
6. Software Engineering Institute. *Standard CMMI_{SM} Appraisal Method for Process Improvement (SCAMPISM), Version 1.1: Method Definition Document*, by Assessment Method Integrated Team. Pittsburgh, Pennsylvania, Carnegie Mellon University, SEI, 2001. (CMU/SEI-2001-HB-001, handbook UNCLASSIFIED.)
7. ———. *Handbook for Conducting Standard CMMI Appraisal Method for Process Improvement (SCAMPI) B and C Appraisals, Version 1.1*, by Will Hayes, Gene Miluk, Lisa Ming, Margaret Glover, and members of the SCAMPI B and C Project. Pittsburgh, Pennsylvania, Carnegie Mellon University, SEI, 2005. (CMU/SEI-2005-HB-005, handbook UNCLASSIFIED.)

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ACRONYMS

AEA	Airborne Electronic Attack
AFCEA	Armed Forces Communications and Electronics Association
ARBS	Angle Rate Bombing System
ARC	Appraisal Requirements for CMMI
ARM	Anti-Radiation Missile
AVJMPS	AV-8B Joint Mission Planning System
AWL	Advanced Weapons Lab
BLK	Block
CBA IPI	CMM-Based Appraisal for Internal Process Improvement
CCHPO	Commonwealth Centers for High Performance Organizations
CM	Configuration Management
CMMI	Capability Maturity Model Integration
CNO	Chief of Naval Operations
DMAIC	Define, Measure, Analyze, Improve, Control
DOD	Department of Defense
DoN CIO	Department of the Navy Chief Information Officer
EPG	Engineering Process Group
EV	Earned Value
EVMS	Earned Value Management System
EW	Electronic Warfare
GWT	Global War on Terrorism
HPO	High Performance Organization
ICAP	Initial Capability
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEPR	Independent Expert Program Review
IOC	Initial Operational Capability
ISO	International Organization for Standardization
JSF	Joint Strike Fighter
JSSA	Joint System Support Activity
KSLOC	One thousand source lines of code

LOE	Level of Effort
MAIS	Major Automated Information System
MDAP	[U.S. DOD] Major Defense Acquisition Program
MR	Management Reserves
MSC	Mission Systems Computer
NAE	Naval Aviation Enterprise
NAVAIR	Naval Air Systems Command
NCW	Network-Centric Warfare
NDIA	National Defense Industrial Association
NSSC	NAVAIR Software/Systems Support Center
NTS	Night Targeting System
OFP	Operational Flight Program
OTRR	Operational Test Readiness Review
P3R	People, Process, and Product Resource [group]
PI	Process Improvement
PSP	Personal Software Process
ROI	Return on Investment
RUG	Radar Upgrade
SCAMPI	Standard CMMI Assessment Method for Process Improvement
SE	System Engineering
SEI	[Carnegie Mellon University] Software Engineering Institute, Pittsburgh, Pennsylvania
SEPG	Software Engineering Process Group
SLOC	Source Lines of Code
SMUG	Stores Management Upgrade
SPI	Software Process Improvement
SPI CoP	Software Process Improvement Community of Practice
SPR	Software Problem Report
SSA	Software Support Activity
STR	System Trouble Report
S/W	Software
SW-CMM	Software-CMM
SWDTT	Software Development Task Team
SWIP	Software Improvement Program
TACAIR	Tactical Aircraft

TPI	Team Process Integration
TSP CoP	Team Software Process Community of Practice
TSPm	Team Software Process for Multiple Teams
TUG	TSP Users Group
UAV	Unmanned Aerial Vehicle
UPC	Unique Planning Component
V&V	Verification and Validation
WBS	Work Breakdown Structure
WD	Weapons Division
WDR	WSSL Discrepancy Reporting
WSSL	Weapon System Support Laboratory

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